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THE FATIGUE STRENGTHS OF SOME WROUGHT ALUMINUM ALLOYS

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13

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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THE FATIGUE STRENGTHS OF SOME WROUGHT ALUMINUM ALLOYS

By G. W. Stickley

The strength of a metal when subjected to repeated stress is usually indicated by a value known as the endurance limit, which generally is defined as the maximum stress that the metal will withstand for an indefinitely large number of cycles of complete reversals of stress. In many design problems, however, such an endurance limit value does not furnish sufficient information concerning the fatigue strength for the anticipated service conditions. It is frequently unnecessary to design for a number of cycles greater than a small fraction of that required in determining the endurance limit. In such cases the desired data can usually be obtained from the fatigue curve used in determining the endurance-limit value. Furthermore, some design problems involve loading conditions in which the stresses are not completely reversed. Therefore, it often is desirable in fatigue testing to make many more tests than the small number required to determine the usual endurance limit value of a metal.

The fatigue strengths that have been determined for several wrought-aluminum alloys at different numbers of cycles and for different ranges of stress were included in tables 5 and 6 of the Structural Aluminum Handbook (1938 and 1940 ed). Parts of the tables are incomplete because all of the necessary fatigue tests had not been finished at the time the Handbook was published. From additional data obtained since that time, the tables have been recently revised. The revisions include small changes in a few of the values, additional data for some of the alloys, and values for two alloys for which data were not available when the Handbook was published.

The revised data, which are summarized in tables I to V, include the fatigue strengths of 14S-T, 17S-T, 24S-T, 52S-3/4H, and 53S-T. Each table includes values from rotating-beam tests and from direct-stress tests. The rotating-beam tests were made in the R. R. Moore type of machine described in reference 1 in which the specimen is

part of a simple beam. In these tests only the extreme fibers are subjected to the maximum stresses, and the tests can be made using only completely reversed stresses. The machines used in making the direct-stress tests have previously been described. (See reference 2.) The entire cross section at the minimum diameter of the specimens is uniformly subjected to the applied fatigue stresses. The range of stress used may be entirely in tension, entirely in compression, or in both tension and compression. The difference in stress distribution is believed to be at least partly responsible for the fact that, for comparable tests with completely reversed stress, the direct-stress results obtained to date are always somewhat lower than those obtained in the rotating-beam test.

The direct-stress tests of each alloy were made on a single lot of material which, at the time it was fabricated, was considered representative of the alloy. Because of improvements in fabrication practices, however, further revision of some of the data included in this memorandum may have to be made when additional tests are completed. Such tests are in progress but, because a series of tests of an alloy requires a considerable length of time, the results will not be available in the near future. Therefore, this memorandum, which cannot be considered final, will be revised from time to time.

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REFERENCES

1. Anon.: Report of Research Committee on Fatique of Metals. A.S.T.M. Proc., vol. 30, pt. I, 1930, p. 259.

2. Templin, R. L.: The Fatique Properties of Light Metals and Alloys. A.S.T.M. Proc., vol. 33, pt. II, 1933, pp. 364-380.

TABLE I

FATIGUE STRENGTHS OF 14S-T

[P. T. Nos. 122932-F and 100738-C]

Kind of test	Minimum stress in each cycle (lb/sq in.)	Approximate maximum stress that alloy will withstand for various numbers of cycles (lb/sq in.)				
		100,000 cycles	1,000,000 cycles	10,000,000 cycles	100,000,000 cycles	500,000,000 cycles
Rotating-beam	(Reversed stress)	±32,000	±27,000	±22,500	±18,500	±16,000
Direct-stress	-25,000	37,000	26,000	15,000	6,000	4,000
	-20,000	41,000	30,000	20,000	11,000	9,000
	-15,000	44,000	33,000	24,000	16,000	14,000
	-10,000	46,000	36,000	28,000	21,000	19,000
	-5,000	48,000	39,000	32,000	26,000	24,000
	0	50,000	42,000	36,000	30,000	28,000
	5,000	52,000	45,000	40,000	35,000	33,000
	10,000	54,000	48,000	43,000	39,000	37,000
	15,000	56,000	50,000	46,000	43,000	41,000
	20,000	58,000	53,000	50,000	47,000	46,000
	25,000	60,000	56,000	53,000	51,000	50,000

TABLE II

FATIGUE STRENGTHS OF 17S-T

[P. T. Nos. 051633-A and 112739-D]

Kind of test	Minimum stress in each cycle (lb/sq in.)	Approximate maximum stress that alloy will withstand for various numbers of cycles (lb/sq in.)				
		100,000 cycles	1,000,000 cycles	10,000,000 cycles	100,000,000 cycles	500,000,000 cycles
Rotating-beam	(Reversed stress)	±37,000	±29,000	±21,000	±17,000	±16,000
Direct-stress	-25,000	28,000	19,000	11,000	4,000	2,000
	-20,000	31,000	23,000	15,000	8,000	6,000
	-15,000	34,000	26,000	19,000	13,000	10,000
	-10,000	37,000	30,000	23,000	17,000	14,000
	-5,000	40,000	33,000	26,000	21,000	18,000
	0	42,000	35,000	29,000	24,000	22,000
	5,000	44,000	38,000	32,000	28,000	26,000
	10,000	47,000	41,000	35,000	31,000	29,000
	15,000	49,000	43,000	38,000	35,000	33,000
	20,000	51,000	46,000	42,000	38,000	36,000
	25,000	53,000	48,000	44,000	41,000	39,000

TABLE III

FATIGUE STRENGTHS OF 24S-T

[P. T. Nos. 020938-D and 111038-B]

Kind of test	Minimum stress in each cycle (lb/sq in.)	Approximate maximum stress that alloy will withstand for various numbers of cycles (lb/sq in.)				
		100,000 cycles	1,000,000 cycles	10,000,000 cycles	100,000,000 cycles	500,000,000 cycles
Rotating-beam	(Reversed stress)	±39,000	±32,000	±25,000	±19,500	±18,000
Direct-stress	-25,000	40,000	28,000	18,000	8,000	6,000
	-20,000	42,000	32,000	22,000	13,000	11,000
	-15,000	44,000	34,000	26,000	18,000	16,000
	-10,000	46,000	37,000	29,000	22,000	20,000
	-5,000	48,000	40,000	33,000	26,000	24,000
	0	50,000	42,000	36,000	30,000	28,000
	5,000	51,000	45,000	39,000	34,000	32,000
	10,000	53,000	47,000	42,000	38,000	36,000
	15,000	54,000	49,000	45,000	42,000	40,000
	20,000	55,000	51,000	48,000	46,000	45,000
	25,000	57,000	53,000	51,000	50,000	49,000

TABLE IV

FATIGUE STRENGTHS OF 52S-3/4H

[P. T. Nos. 103033-B and 080935-D]

Kind of test	Minimum stress in each cycle (lb/sq in.)	Approximate maximum stress that alloy will withstand for various numbers of cycles (lb/sq in.)				
		100,000 cycles	1,000,000 cycles	10,000,000 cycles	100,000,000 cycles	500,000,000 cycles
Rotating-beam	(Reversed stress)	±26,000	±23,000	±21,000	±20,000	±20,000
Direct-stress	-25,000	17,000	9,000	6,000	5,000	4,000
	-20,000	22,000	14,000	12,000	11,000	10,000
	-15,000	26,000	19,000	17,000	16,000	15,000
	-10,000	30,000	24,000	22,000	21,000	20,000
	-5,000	33,000	28,000	26,000	25,000	24,000
	0	36,000	32,000	30,000	29,000	28,000
	5,000	37,000	34,000	33,000	32,000	31,000
	10,000	38,000	36,000	34,000	34,000	33,000
	15,000	38,000	37,000	35,000	35,000	35,000
	20,000	38,000	37,000	36,000	36,000	36,000
	25,000	38,000	38,000	37,000	37,000	37,000

TABLE V

FATIGUE STRENGTHS OF 53S-T

[P. T. Nos. 112932-C and 080935-E]

Kind of test	Minimum stress in each cycle (lb/sq in.)	Approximate maximum stress that alloy will withstand for various numbers of cycles (lb/sq in.)				
		100,000 cycles	1,000,000 cycles	10,000,000 cycles	100,000,000 cycles	500,000,000 cycles
Rotating-beam	(Reversed stress)	±25,000	±20,000	±16,000	±12,000	±11,000
Direct-stress	-20,000	19,000	12,000	6,000	2,000	1,000
	-15,000	23,000	16,000	11,000	7,000	6,000
	-10,000	26,000	20,000	15,000	11,000	10,000
	-5,000	28,000	24,000	19,000	16,000	14,000
	0	30,000	26,000	23,000	20,000	18,000
	5,000	31,000	29,000	26,000	24,000	22,000
	10,000	33,000	31,000	29,000	28,000	26,000
	15,000	34,000	32,000	31,000	29,000	28,000
	20,000	35,000	34,000	33,000	32,000	31,000